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SMART GEOSPATIAL TECHNOLOGIES AND SPATIAL DATA ANALYSIS: AI, REMOTE SENSING AND 3D MODELLING FOR ENVIRONMENTAL, LAND USE AND URBAN APPLICATIONS

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The fast advancement of digital spatial modeling, artificial intelligence (AI), satellite Earth observation systems, and geospatial technologies is revolutionizing the monitoring, analysis, and management of Land Use, Urban, and Environmental processes. With the ability to automate feature extraction, pattern recognition, spatial prediction, geospatial data fusion, and the analysis of ever-larger and more diverse Earth observation datasets. AI has emerged as one of the key forces behind innovation in Geographic Information Systems (GIS) (Zhu et al., 2017; Reichstein et al., 2019). Researchers can now tackle increasingly complex spatial problems across multiple spatial and temporal scales thanks to the growing availability of high-resolution remote sensing imagery, mobile mapping systems, LiDAR (Light Detection and Ranging) technologies, cloud computing platforms, and machine-learning approaches. Because of this, geospatial science has changed from being solely concerned with gathering and mapping data to being an integrated framework that facilitates intelligent spatial analysis, forecasting, and decision-making.

Seven contributions from academics from Europe and Asia are included in the Special Issue “Smart Geospatial Technologies and Spatial Data Analysis: AI, Remote Sensing and 3D Modeling for Environmental, Land Use and Urban Applications” (as mentioned in the Table). The chosen manuscripts address a wide range of subjects, such as advanced 3D modeling, Land Use dynamics, Urban systems analysis, Environmental monitoring, and Spatial pattern recognition. The use of remote sensing, spatial data analytics, and AI-supported geospatial techniques, which are becoming essential elements of contemporary GIS and Earth observation research, is given particular focus (Zhu et al., 2017; Reichstein et al., 2019; Janowicz et al., 2020). Together, these publications show how contemporary

geospatial techniques enable climate studies, infrastructure design, urban planning, land management, environmental monitoring, and geographic decision support systems. Despite the fact that the studies’ application domains are different, they all share a methodological foundation that integrates spatial data, geospatial analysis, remote sensing observations, modeling methodologies, and new intelligent technologies.

The authors’ extensive use of geographic data sources is one of the Special Issue’s noteworthy features. These include digital terrain models, GIS-based spatial databases, smartphone-based LiDAR sensors, satellite imagery, GNSS observations, mobile mapping systems, and climatic and meteorological datasets. Simultaneously, a number of contributions show how machine learning, expert systems, and automated spatial modeling are becoming more important elements of next-generation geospatial workflows.

One of the most important environmental issues related to urbanization is discussed in the first publication, “Analysis of urban heat islands in the study of urban environmental problems based on remote sensing.” The authors present the development of urban heat islands in three Azerbaijani cities using Landsat 8 thermal images and GIS-based spatial analysis. The study shows how remote sensing technologies can be used to enhance climate-resilient urban planning, detect thermal hotspots, and evaluate fluctuations in land surface temperature. The conversion of remote sensing data into useful suggestions for urban environmental management and adaptation tactics is very beneficial.

The continuing presentation of geospatial data gathering technology is reflected in the second contribution, “Possibilities of using the mobile device viDoc RTK rover for the real estate cadastre”. The authors assess a portable

Table. Content of the special issue

	Title of the paper	Authors of the paper	Country
First paper	Analysis of urban heat islands in the study of urban environmental problems based on remote sensing	Shahnaz Manova, Afag Hajiyeva, Leyla Ibrahimova, Firuza Jafarova	Azerbaijan
Second paper	Possibilities of using the mobile device viDoc RTK rover for the real estate cadastre	Petr Jadvíšek, Tereza Jadvíšková, Jiří Plesník, Hana Staňková	Czech Republic
Third paper	Modulation of ETCCDI-based extreme rainfall indices by ENSO and the Indian Ocean Dipole over topographically complex North Sumatra, Indonesia	Muchamad Nur, Khomsin, Danar Guruh Pratomo, Muhamad Sawal	Indonesia
Fourth paper	Performance evaluation of smartphone-based LiDAR for indoor 3D modelling applications	Muhammad Ulin Nuha, Antonius Tambunan, Aldino Rizaldy, Fadhilurrahman Nefrin, Rizqi Aulia, Roy Candra P. Sigalingging	Indonesia, Germany
Fifth paper	Determining strategic locations for rental housing development with GIS and expert systems around the educational area of Universitas Sulawesi Barat	Ade Mulawarman, Farid Wajidi, Rahmiyatal Munaja, Muhammad Arhim	Indonesia
Sixth paper	Temporal and spatial patterns of PM2.5 in Mainz, Germany: insights from satellite observations and machine learning	Felien Tee, Hakan Lane	Netherlands, Germany
Seventh paper	Geodetic support and automated vertical planning in the design of a karting complex using Autodesk Civil 3D	Ani Stefanova, Ana Dimitrova	Bulgaria

mobile GNSS solution's suitability for cadastral surveying jobs and contrast its effectiveness with traditional geodetic techniques. The study adds to the expanding conversation on affordable positioning technologies and their possible application in land administration and cadastral applications, where accuracy standards are still crucial.

The third study, "Modulation of ETCCDI-based extreme rainfall indices by ENSO and the Indian Ocean Dipole over topographically complex North Sumatra, Indonesia," focuses on climate variability and environmental risk assessment. The authors present how regional rainfall extremes are influenced by large-scale climate oscillations by combining satellite precipitation records with long-term station observations. The study emphasizes the need for geospatial climate analytics for disaster risk reduction and climate adaptation planning, and it offers significant insights into spatiotemporal patterns of intense precipitation.

The fourth paper, "Performance evaluation of smartphone-based LiDAR for indoor 3D modeling applications," discusses the capture of 3D spatial data. Assessing the measurement quality of consumer devices becomes crucial as LiDAR technology is incorporated into more and more of them. The authors offer a comprehensive evaluation of geometric accuracy, point density, and surface representation quality by contrasting smartphone-generated point clouds with data from terrestrial laser scanning. The study illustrates the potential and constraints of inexpensive LiDAR technologies for real-world 3D modeling applications.

The function of GIS-based spatial decision support systems in urban and regional planning is demonstrated in the fifth paper, "Determining strategic locations for rental housing development with GIS and expert systems around the educational area of Universitas Sulawesi Barat". The authors create a methodology for determining appropriate sites for housing development in quickly expanding

school districts by combining the Analytic Hierarchy Process with Spatial Multi-Criteria Analysis. The study shows how land-use decision-making may successfully include environmental, socioeconomic, and policy-related factors using geospatial technologies.

The sixth study, "Temporal and spatial patterns of PM2.5 in Mainz, Germany: insights from satellite observations and machine learning" discusses air quality monitoring and spatial prediction. The study analyzes long-term particulate matter dynamics using statistical and machine-learning techniques in conjunction with satellite-derived environmental measurements. The authors illustrate the increasing significance of incorporating remote sensing data and artificial intelligence tools in environmental monitoring and public health evaluation by contrasting interpolation and predictive modeling approaches.

The integration of digital terrain modeling, engineering design automation, and geodetic surveying is highlighted in the final publication, "Geodetic support and automated vertical planning in the design of a karting complex using Autodesk Civil 3D." The workflow that is being given shows how parametric modeling techniques in contemporary geospatial software systems enable effective infrastructure planning, enhance design uniformity, and minimize engineering labor. The ongoing significance of geodetic data as a basis for intelligent engineering design systems is demonstrated by this contribution.

When considered collectively, the articles in this Special Issue amply illustrate the continuous shift toward intelligent and data-driven geospatial science. The contributions reveal a number of general patterns. First, satellite remote sensing is becoming more and more useful for predictive and decision-oriented applications, going beyond simple observation. Second, for many surveying and mapping jobs, mobile and inexpensive geospatial technologies are

emerging as competitive alternatives. Third, workflows for geographical analysis are increasingly including machine learning and artificial intelligence. Lastly, more thorough solutions to issues pertaining to the environment, cities, and infrastructure are made possible by the integration of various geographic information.

The editors expect that this Special Issue will help scholars in geodesy, cartography, GIS science, remote sensing, urban studies, environmental sciences, and spatial data analytics collaborate more across disciplinary boundaries. Together, the findings show that intelligent geospatial technologies not only improve scientific knowledge of spatial phenomena but also offer useful tools for tackling some of the most important social and environmental issues of our day.

References

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